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ARMSTRONG

OILY WASTE DISPOSAL SURVEY SOUTH TANK FARM, LAJES FIELD, AZORES

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LABORATORY

March 1991

Final Technical Report for Period 12 June 1990 – 17 June 1990

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235-5601

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13. ABSTRACT (*Maximum 200 words*)

A survey of the wet and dry sludge pits at the South Tank Farm, Lajes Field, Azores was performed by members of the AFOEHL. Samples of the wastewater and sludge from the wet sludge pit (WSP) were taken as well as from the dry sludge pit. Bioremediation studies, incineration, and carbon adsorption studies were performed at AFOEHL. The characterization of the wastewater from the WSP revealed a one phase mixture of mostly soluble oils and grease with an average COD concentration of 1760 and a BOD of 407 mg/l. Oils and grease concentrations were in the 10 mg/l range. The characterization of the sludge revealed a sludge with 43% organics and concentrations of metals not high enough for consideration as hazardous waste. The sludge from the DSP also did not have levels of metals high enough for special disposal as hazardous waste. The WSP wastewater was slow to degrade biologically through stimulation of indigenous organisms. Carbon was effective in removing COD. The WSP wastewater has subsequently been released to the Praia Bay and the sludge recovered and drummed. Recommendations included the construction of a secondary sewage treatment plant to service the base, airport, and Praia, the construction of a sludge drying facility and testing of the dried sludge for ultimate disposal

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I. INTRODUCTION

The Air Force Occupational and Environmental Health Laboratory (AFOEHL) has been involved with assisting HQ MAC/SGPB and DEEV in resolving the sludge problem at the South Tank Farm (STF) Lajes Field, Azores since the original request for assistance in 25 January 1989. A response was prepared in April 1989 based on the available data and forwarded proposing possible methods of remediation. Subsequently, AFOEHL was asked to determine the best remediation method, considering cost and environmental acceptability. A team from AFOEHL, Environmental Quality Division (EQ) conducted an on-site survey from 12 to 17 June 1990 in support of this request. The following AFOEHL personnel participated in the South Tank Farm survey:

Lt Col Robert D. Binovi, AFOEHL Chief Engineer
TSgt Mary K. Fields, Environmental Quality Division Technician
Sgt Robert P. Davis, Environmental Quality Division Technician
Sgt Stanley Dabney, Environmental Quality Division Technician

A hazardous waste management survey was conducted concurrently by Capt Patrick McMullen and 1Lt Nancy Hedgecock, Environmental Quality Division, Hazardous Waste Branch. Their findings and conclusions are under separate cover.

II. DISCUSSION

A. South Tank Farm (STF)

1. Background

a. The wet sludge pit (WSP) occupied about 12,500 square feet (1/4 acre) and ranged in depth from 2.5-4 feet. The sludge depth varied as well; near the gate the depth was more than a foot while areas adjacent had no apparent depth. There seems to have been two sources of sludge: (1) dumping from the accessible portions and (2) the deposition of naturally occurring soils and sands from run-off from the adjacent ridge.

b. The wet sludge pit at the STF was constructed in 1986 for use by the contractor during construction of new tanks there. It was used for disposal of fuel, water, and sludge removed from the old tanks prior to their demolition. It has remained, at the Air Force request, to be used for the disposal of sludge and fuel from tanks converted from JP-4 to JP-8 and for future tank cleaning projects. (1)

c. On 8 July 1989, a Portuguese employee working at the STF drained the water from the WSP to lower the level. The water was siphoned from the middle of the tank and allowed to drain by grade into a drainage ditch. This above-ground flow then entered a conduit to pass under a road and parking area and into the shallow waters of Praia Bay at the marina bulkhead (2). Evidently a fish kill occurred and the University of the Azores conducted sampling. This led to official Portuguese allegations that the U.S. Air Force was polluting/endangering the environment by discharging

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NOTE: This report was accomplished by the Air Force Occupational and Environmental Health Laboratory (AFOEHL), which is now the Armstrong Laboratory, Occupational and Environmental Health Directorate.

contaminants from the STF into Praia Bay. The USAF/Clinic SGPB conducted sampling, and in a reply to the allegation routed through Headquarters Azores Air Command, the Headquarters of the Commander, United States Forces Azores/J4 reviewed the sampling results of the University of Azores and generally discredited a connection with the incident and the sampling results. With no criteria for discharge of this nature, the results were compared with Resource Conservation and Recovery Act (RCRA) criteria for characteristic hazardous waste.

d. The South Tank Farm was located on or very near a major geological fault (Allen and Hoshall Engineering Report, 1990). It was also located near Praia Da Vitoria well D, about 3000 feet away. Situated in the base of a ridge, the pit was susceptible to both run-off from the ridge and infiltration from the water table, possibly filling with groundwater during times of wet weather, or leaking into the groundwater in periods of dry weather.

e. Lajes AB discharged an estimated 695,000 gallons of untreated combined wastewater into the ocean a day (3). During wet weather peak flows would approach 2.78-million gallons per day (MGD). The outfall pipe discharged from a 40-foot cliff, 200 feet to the surf. The ocean at this location was 60-75 feet deep for about 1500 feet and then dropped off to 2000 feet deep.

2. Applicable Regulations and Limitations

a. Portuguese regulation Decree-Law 90/71, March 22, 1971 bans discharge of noxious waste in coastal waters, including docks, ports and maritime zones of rivers. The substances banned include crude oil and gasoline. Penalties (up to one million escudos) can be assessed.(4)

b. Portugal was a participant of the Paris Convention for the Protection of Marine Pollution from Land-Based Sources, June 1974. This convention sought to eliminate pollution of maritime areas by land-base sources which would (1) give rise to dangerous accumulations of harmful materials in the food chain; (2) endanger the welfare of living organisms causing undesirable changes in the marine ecosystems; (3) interfere seriously with the harvesting of sea foods or with other legitimate uses of the sea; or (4) contain

(a) organohalogen compounds and substances which may form such compounds in the marine environment,

(b) mercury and mercury compounds,

(c) cadmium and cadmium compounds,

(d) persistent synthetic materials which may float, remain in suspension or sink and interfere with the legitimate use of the sea, or

(e) persistent oils and hydrocarbons of petroleum origin.

c. This convention also sought to strictly limit pollution from

(1) organic compounds of phosphorous, silicon, tin, and substances which may form such compounds,

(2) element phosphorous,

(3) nonpersistent oils and hydrocarbons of petroleum origins,

(4) element and compounds of arsenic, chromium, copper, lead, nickel, and zinc, and

(5) other substances having a deleterious effect on the taste and smell of products derived from the marine environment.

B. The AFOEHL Ecology Function performed a bioassay for evaluation of the toxicity of the wet sludge pit water. The aquatic fish species, Pimephales Promelas (fathead minnow) were exposed to various dilutions of water in a 96-hour bioassay. The data sheet is included as Appendix A. The LD50 of the water in percent was found to be 27%. That meant that 50% of the fish exposed to a 27% solution of this wastewater mixed with a clean buffered water would be expected to be killed in 96 hours.

C. The wastewater was a concentrated industrial waste with a chemical oxygen demand (COD) slightly less than 2,000 mg/L. It was primarily of one phase (the lighter oily phases had been skimmed previously); therefore, the toxicity would be little reduced by passing it through an oil/water separator. The sludge contained about 45% moisture, with the solids being roughly half organic and half inorganic in nature.

D. Sampling for various other parameters was performed on the wastewater, sludge, and dried sludge. Bottom depths and sludge depths were measured with a "Sludge Judge," a graduated Plexiglas apparatus that allows the capture and measurement of a column of sludge. Parameters such as PCB, oils and grease, volatile organic compounds, biochemical oxygen demand (BOD), metals, and BTU value all had direct bearing on the possibilities of acceptable disposal.

Sampling Results

a. WSP Wastewater: The volume of sludge and wastewater in the pit calculated to about 234,000 gallons. About 208,000 gallons of wastewater were determined (Appendix C). Two water sampling sites were selected as shown on the site plan, Figure 1. The characteristics of the wastewater revealed an orange colored water with characteristic petroleum odor. Analyzed on site, the average suspended solids concentration was 208 mg/L. The average biochemical oxygen demand (BOD) and chemical oxygen demand (COD) 407 were 1760 mg/L. COD analyzed at the OEHL averaged 1740 mg/L and Total Organic Carbon (TOC) averaged 360 mg/L. The sampling for volatile organic compounds (EPA methods 601 and 602) showed no significant concentrations. Soluble metals at concentrations above detection averaged Ca 22.9 mg/L, Fe 17.9 mg/L, Mn 1.13 mg/L, Zn 0.58 mg/L, Al 1.29 mg/L, Mg 8.0 mg/L, Pb 0.69 mg/L, Ba 0.11 mg/L. Results are tabularized in Appendix B.

b. WSP Sludge: Sludge depths were measured by the "Sludge Judge" from a boat. Measurement was curtailed before depths at each of the 10 feet by 10 feet grid points could be completed, as the boat began to sink. Thirty-three points were recorded. The total volume of wet sludge was

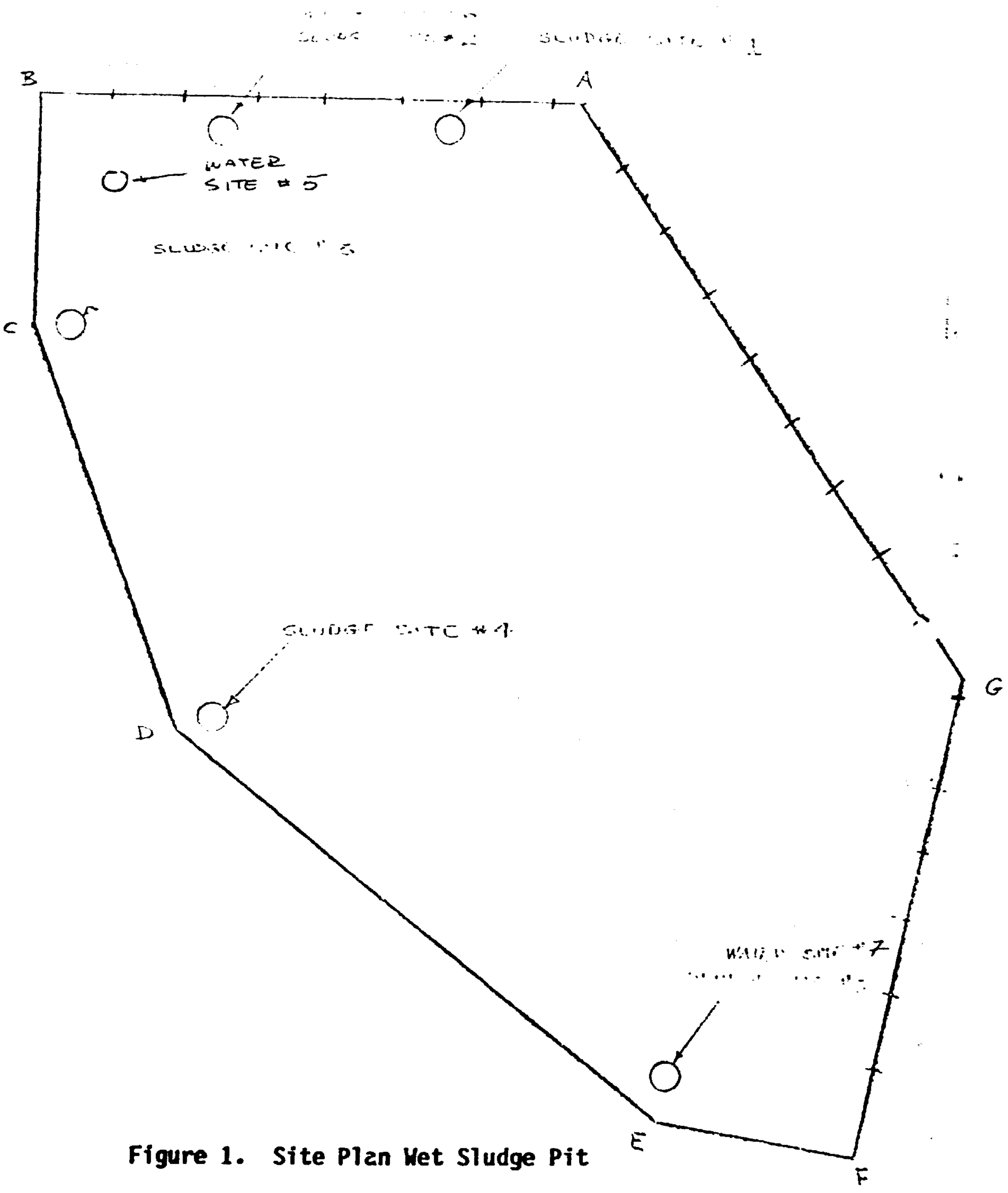

Figure 1. Site Plan Wet Sludge Pit

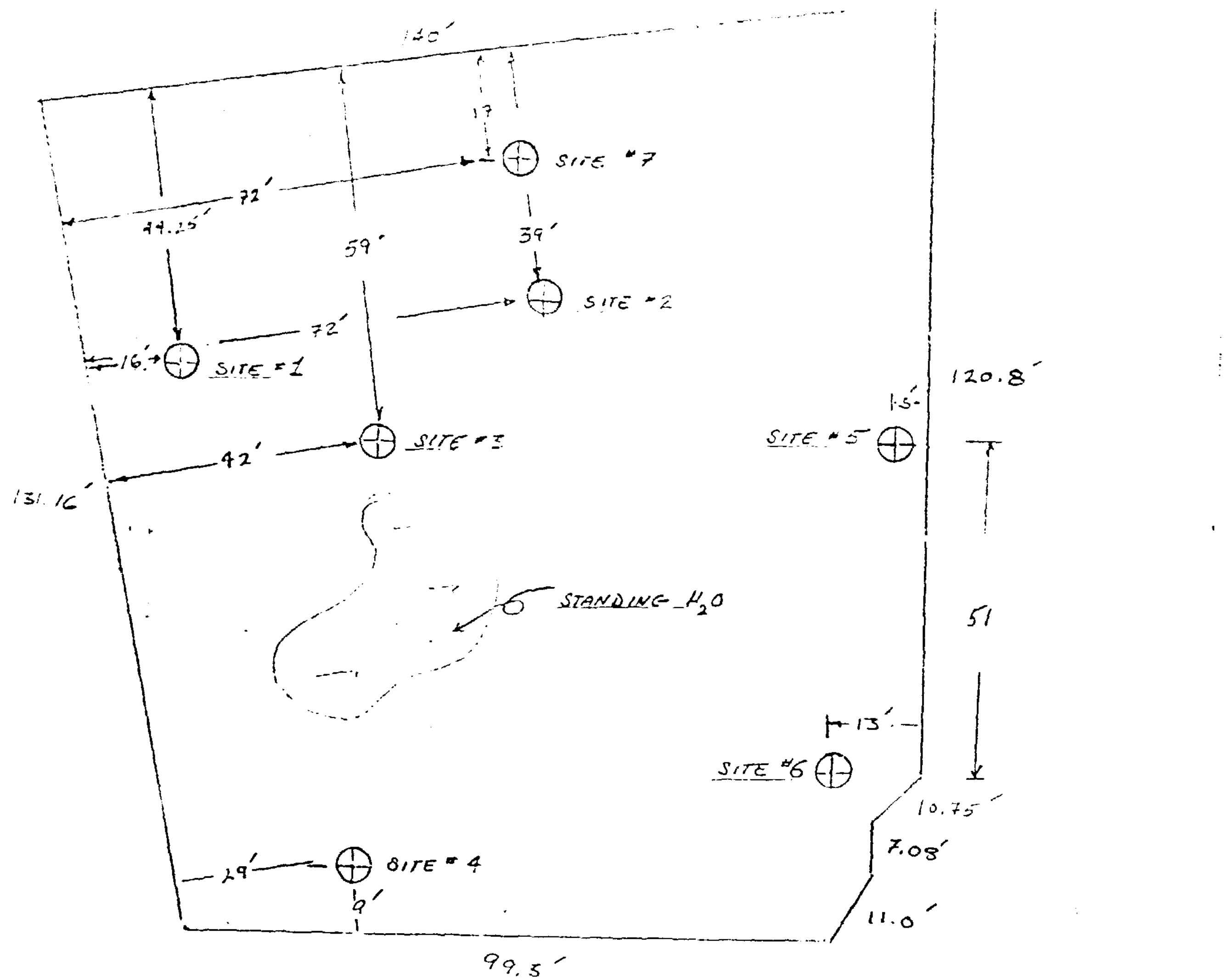

Figure 2. Site Plan, Dry Sludge Pit

SAMPLING LOCATIONS
AZORES, LAJES
SOUTH TANK FARM
DRY SLUDGE PIT

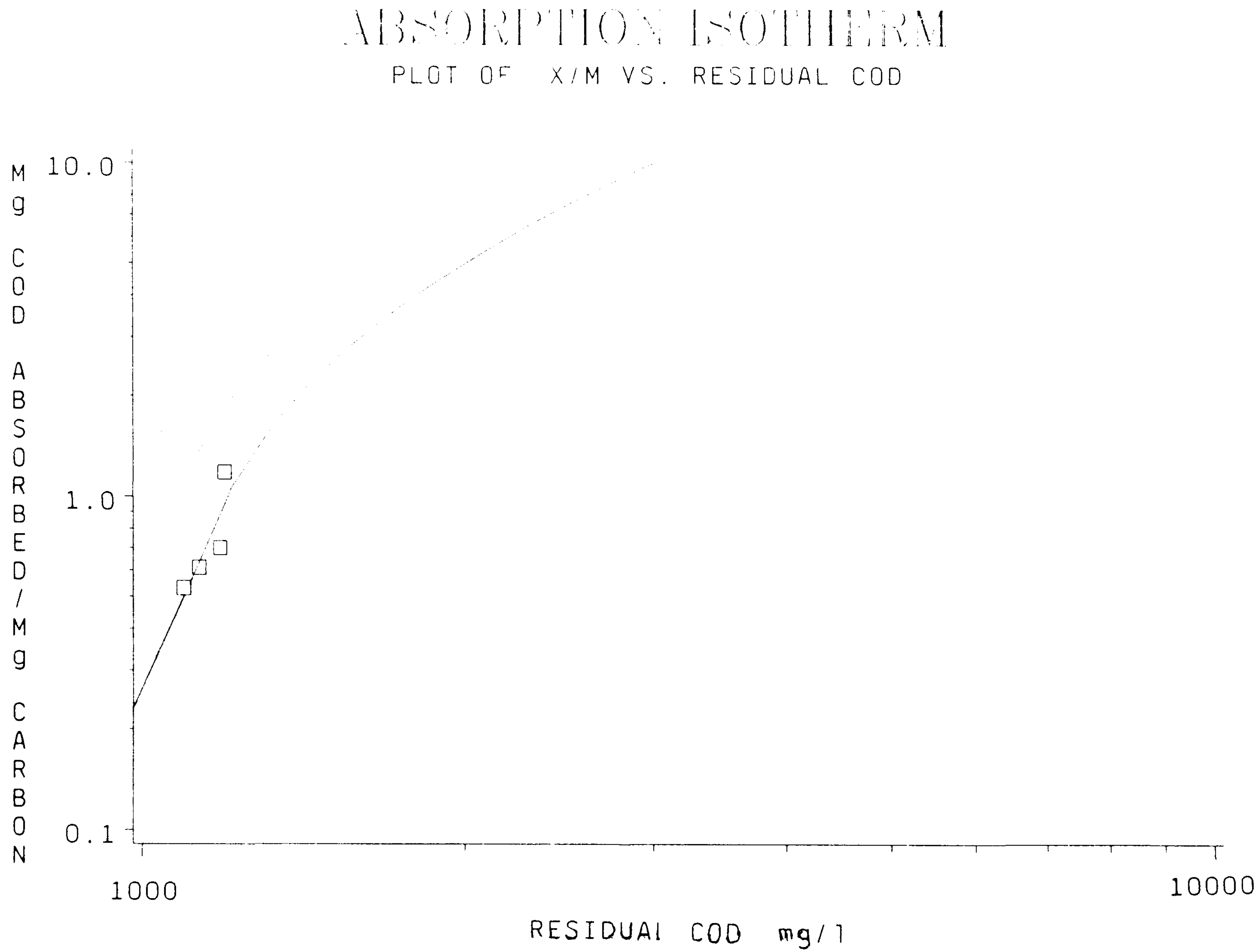

Figure 3. Adsorption Isotherm

estimated at 5600 cubic feet (207 cubic yards). Computations are included in Appendix D. Based on the average of 78% moisture content from drying at 103 degrees C, about 1200 cubic feet (45 cubic yards) of dry sludge could be expected. The sludge was black colored with characteristic petroleum odor. Three sites (locations shown in Figure 1) were selected to provide characterization of the sludge. Sludge results are tabularized in Appendix B. EP Metals concentrations were below detectable limits except for chromium found at the detectable limit of 0.1 mg/l at Site 2 and at Site 3 at 0.4 mg/l.

c. Dry Sludge Pit Soil: The dry sludge pit was a fenced-in site of approximately .34 acres. Portions of the pit were bermed and lined. Sampling from seven sites was conducted. Site locations are shown in Figure 2. Samples from the top layer of soil were removed and analyzed at the AFOEHL. Results are tabularized in Appendix B. Concentrations of metals were very low in the soil and most samples were below detection limits. Samples with metals concentrations above detection were Cr 0.5 mg/l and Cd 0.7 mg/l at Site 3 and Pb of 0.3 mg/l at Site 6. EPA 8080 Method analytes were below detection limits. Soil results are tabularized in Appendix B.

E. A bench-scale bioreactor was set up at the AFOEHL to explore the possibilities of in-situ bioremediation by aeration and nutrient addition. Nutrient addition followed concentrations used by Fedorak and Westlake (5). The reactor was operated for a period of 45 days with the parameters of COD, BOD, suspended solids, and settleable solids analyzed. The results of this study showed that COD was slowly degraded, at a rate approaching 69 mg/L-day as determined if the reaction followed first-order reaction kinetics. Results of the laboratory experiment are contained in Appendix C.

F. Carbon adsorption shaker tests were performed at the AFOEHL to determine the preliminary treatment efficiency. One carbon source was available, activated charcoal, Darco G-60. One hundred milliliter aliquots of wastewater were shaken for two hours with varying amounts of carbon. Concentrations of adsorbed COD were determined and the adsorption isotherm shown in Figure 3 was generated. From the isotherm 0.25 mg of COD per mg carbon might be expected to be adsorbed at equilibrium. However, additional testing with other types of carbon and pilot plant column studies would need to be performed if carbon treatment is considered for treatment of this type wastewater.

G. Sludge drying and incineration studies were also performed. Although caloric or heating value was to be determined in the sludge, the Fuels Lab at Wright-Patterson AFB decided not to perform them, citing that our ASTM method for determining the heating value of sludge (closed cup bomb colorimetry) as inappropriate. The AFOEHL does not have the capability to determine heat content; however, the ability to ignite was observed between 300-350 degrees C. A reduction of 42% in weight was recorded after 30 minutes at 350 degrees C.

H. Because of an initial concern with possible groundwater contamination, and the proximity to a municipal well, a water sample was taken from a four-story apartment complex nearby (8 Camino De Paul). The water, analyzed for volatile organic compounds (VOC) (EPA Methods 502.1 and 503), was free from detectable VOCs.

III. CONCLUSIONS

A. Wastewater Disposal: Subsequent to the finalizing of this report, the wastewater from the WSP had been released to Praia Bay, through the newly constructed oil/water separator. The wet sludge has been removed from the tank and recovered in barrels. The following text prepared before this event, is relevant to possible environmental consequences of this action.

1. Comparisons of wastewater sample results with published chronic marine toxicities (5) are summarized in the following table:

Comparison of Wastewater Results with Published Marine Toxicity

PARAMETER	AVG. CON. ug/L	CHRONIC TOXICITY (ug/l) Acute	Chronic
Manganese	1129	100 ug/L (protection of consumers of marine mollusks)	
Calcium	22,850	No reported toxicity	
Iron	17,865	No reported toxicity	
Zinc	576	95	86
Lead	687	140	5.6
Aluminum	1290	No reported toxicity	
Titanium	<413	No reported toxicity	
Magnesium	8,000	No reported toxicity	
Oil & grease (2 methods of analysis)			
(E418.1)	4,600	100 (marine larvae)	
(IR)	10,050	100 (marine larvae)	

2. The high concentration of oxygen depleting chemicals as measured by BOD and COD, and not any single toxicant, probably was responsible for the marine toxicity apparent in the incident in June 1989. Limited dilution or mixing was possible from the discharge into the shallow, protected bay from the bulkhead. The less dense fresh water tended to form a cover over the more dense salt water of the immediate area near the discharge. In order for water to be released through the culvert in the bulkhead, concentrations of BOD and COD needed to be reduced through treatment or dilution to levels in the 15- and 30-mg/L range, respectively, and the other parameters listed in the table reduced below their acute toxicity values. The wastewater did not appear to have any substances prohibited by name (i.e., mercury and cadmium) above detectable levels in the wastewater.

3. Since the wastewater did not appear to contain prohibited compounds, the wastewater could be diluted by quantities of water of lesser concentration and discharged into areas of already degraded quality as long as the oil or persistent hydrocarbons are removed and the dilution reduces known toxicant concentrations below chronic marine toxicities. The problem in discharging this type wastewater untreated through the existing sewer system is with the oil and grease concentrations. Typical oils and grease concentrations in sewers have been shown to be between 20 and 30 mg/L. With aquatic toxicities in the 0.1 mg/l region, and a dilution factor calculated at 451, the calculated concentration at the plume was 0.066 mg/l, from a formula in Muellenhoff, et al (7). In this case, the WSP wastewater had oil and grease concentrations lower than those typically found in domestic sewage; therefore, a raise in the concentration to 0.1 mg/l, if one relies on dilution calculations, would be unlikely. A plot of dilution factors versus gallons discharged is presented in Figure 4 for disposal at the sewage outfall.

4. Based on the bioremediation testing, in-situ remediation of the WSP by stimulation of indigenous organisms with nutrients would be too slow to be a practical solution because of the slow reaction rate and the slow desorption of hydrocarbons from the sludge. It is difficult to estimate the actual length of time needed to remediate the WSP using nutrient enrichment because of the poor correlation of the bench scale study data to standard first (r=0.05) or second order kinetics. The poor correlation can be explained through equilibria, diffusion and desorption of COD from the sludge. Bioremediation (lowering of BOD or COD) by passing the wastewater through established biomedia (activated sludge or trickling filter) is possible but not demonstrated. The Navy operates an oily wascte treatment plant in Virginia. Wastewater of this type could be removed and placed in tanks on board ship for treatment in such a plant, if it is determined that deep ocean disposal is prohibited or not desired.

5. There are several other treatment options besides bioremediation available for the treatment of wastewater. Each will remove COD and BOD by 90% or better; however, BOD or COD removal may not be sufficient for discharge through the culvert into the bay. The following options are preferred:

a. Ultrafiltration or reverse osmosis treatment (ROPU, reverse osmosis purification units) has been shown to be more than 99% efficient in removing aliphatic hydrocarbons. The Army unit is mobile and could be moved on site readily. The membranes are subject to fouling, though most if not all units have prefiltration to minimize RO membrane fouling. Cellulose acetate membranes will operate effectively at pH values greater than 4.0.

b. Carbon Adsorption demonstrated reasonable COD removal, although the results of the shaker test are by no means conclusive. Passing this type of wastewater through carbon adsorption columns may provide the added degree of treatment needed to discharge WSP-type wastewater to areas with sensitive ecosystems.

B. Wet Sludge Pit (WSP) Sludge Disposal

The principle concerns of sludge disposal are effective volume reduction and an environmentally acceptable ultimate disposal. Based on the

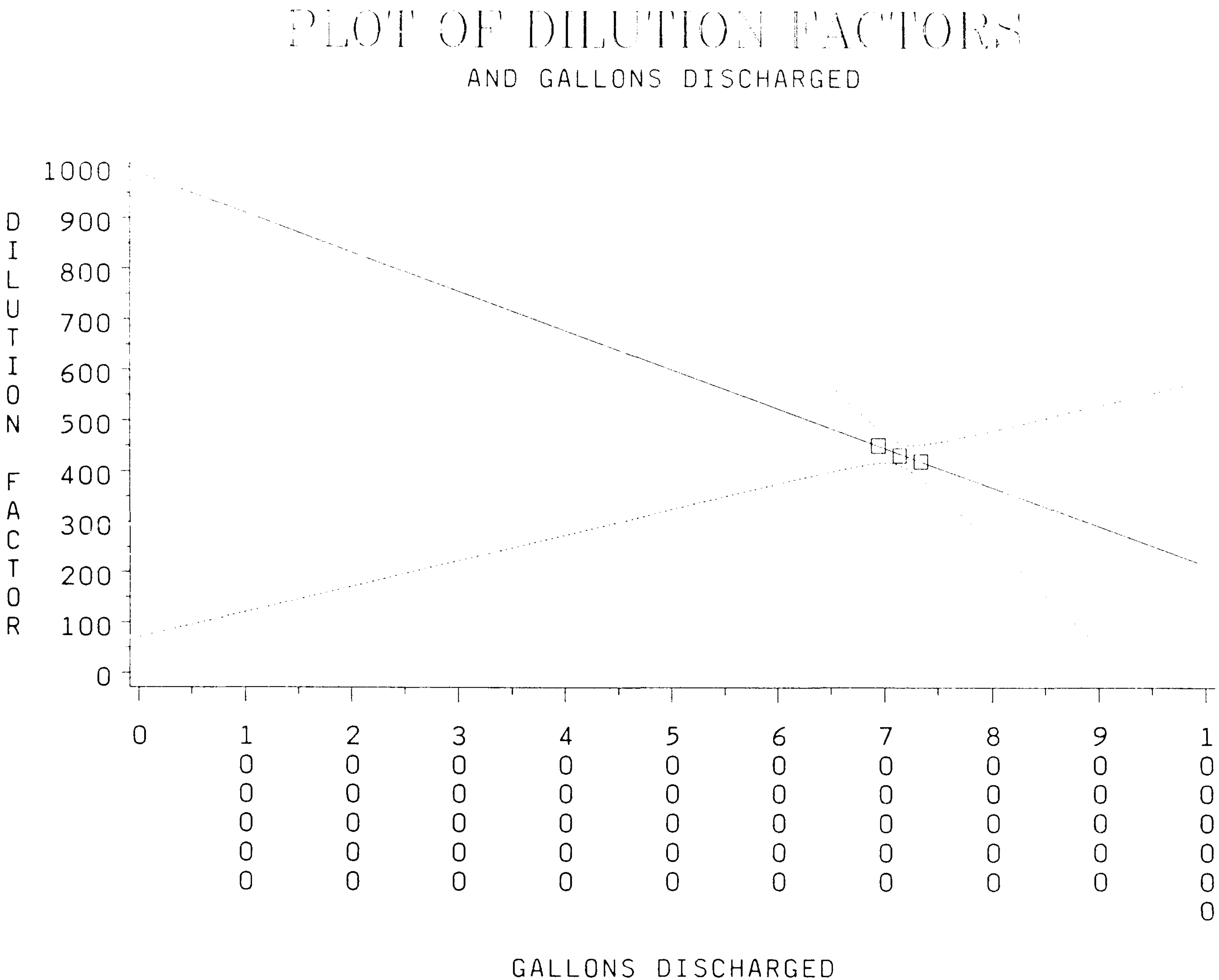

Figure 4. Plot of Dilution Factors and Gallons Discharged

results of the sampling and the general unavailability of sophisticated equipment, air drying or weathering the sludge is a practical and attractive method for volume reduction. Weathering, that is the constant turning of a spread-out sludge under a cover, would provide both biological degradation and loss of moisture content necessary to return the sludge to the soil as fill. At last report the sludge had been barreled up along with considerable water. Unfortunately, since the survey was performed, the accepted method for determining disposal of the sludge (EP toxicity test) has been superseded by the Toxic Characteristic Leaching Procedure (TCLP), adding requirements for additional organic chemical analyses. Based on the absence of volatile organic compounds in the wastewater, these chemicals should be absent from the sludge as well. However, if this waste were to be sent back to the States for disposal, results from testing with the new procedure would be necessary in order to determine disposition.

IV. RECOMMENDATIONS

A. Lajes should provide treatment for its combined sewage. Biological treatment could provide a disposal option for both WSP wastewater and sludge and improve marine water quality. Hazardous materials which are present with any industrial operations should not be allowed to enter the food chain, when in all probability can be removed by treatment. There is no question that the Azores needs to act responsibly and provide regional sewage treatment for Praia, the base, and the airport complex.

B. Oily waste sludge from tank cleaning should be dried under covered structures in the Azores because of the wet climate. Sludge drying in greenhouse structures used for drying domestic sewage sludge seems to be the most economical and practical method of volume reduction. Ventilation should be provided to prevent the build-up of possibly noxious or explosive gas. The dried sludge should be tested to determine if characteristic hazardous waste limits (e.g., TCLP) are exceeded. If the dried sludge is not a characteristic hazardous waste, then it can be tilled into rich soil, using soil microbial populations to further degrade the remaining organic material.

C. If the dried sludge fails the TCLP test, then the dried waste should be containerized and sent back to the States for disposal by a licensed hazardous waste treatment and disposal facility.

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APPENDIX A

AFOEHL Aquatic Bioassay Data Collection Sheet

AFOEHL
AQUATIC BIOASSAY
DATA COLLECTION SHEET

BASE: Lajes Azores SPECIES: Fat Head Minnow AGE: 7 day old

DATE COLLECTION BEGAN: ______ DATE COLLECTION ENDED: ______ DATE RECEIVED: ______

CONTROL HARDNESS: ______ CONTROL ALKALINITY: ______ CONTROL CHLORINE: ______ CONTROL CONDUCTIVITY ______

SAMPLE HARDNESS: ______ SAMPLE ALKALINITY: ______ SAMPLE CHLORINE: ______ SAMPLE CONDUCTIVITY ______

REMARKS: Special Request

CLF — Date: 18 July 90 — Sample #: GN 700U13 — Time: 1100

	CONTROL A	CONTROL B	2.5% A	2.5% B	5% A	5% B	10% A	10% B	20% A	20% B	40% A	40% B	A	B	A	B
NO. ALIVE:	10	10	10	10	10	10	10	10	10	10	10	10				
DISSOLV. O_2:	6.0		6.6		6.6		6.8		7.3							
PH:	7.1		7.2		7.2		7.2		7.1		6.8					
TEMPERATURE:	24.2		24.8		24.6		24.1		24.1		24.3					

24 HRS — CLF — Date: 19 July 90 — Sample #: GN 700U13 — Time: 1430

	CONTROL A	CONTROL B	2.5% A	2.5% B	5% A	5% B	10% A	10% B	20% A	20% B	40% A	40% B	A	B	A	B
NO. ALIVE:	10	10	10	10	10	10	10	10	10	10	10	10				
DISSOLV. O_2:	8.5		8.3		8.3		8.1		8.0		8.0					
PH:	8.2		8.2		8.2		8.1		8.0		7.9					
TEMPERATURE:	24.8		24.7		24.9		24.7		24.6		24.6					

48 HRS — CLF — Date: 20 July 90 — Sample #: GN 700U13 — Time: 1245

	CONTROL A	CONTROL B	2.5% A	2.5% B	5% A	5% B	10% A	10% B	20% A	20% B	40% A	40% B	A	B	A	B
NO. ALIVE:	10	10	10	9	10	10	10	10	9	9	0	0				
DISSOLV. O_2:	8.4		8.3		8.3		7.9		7.4		6.8					
PH:	8.3		8.2		8.3		8.3		8.3		8.1					
TEMPERATURE:	24.5		24.8		24.8		24.7		24.9		24.6					

72 HRS — CLF — Date: 21 July 90 — Sample #: GN 700U13 — Time: 0830

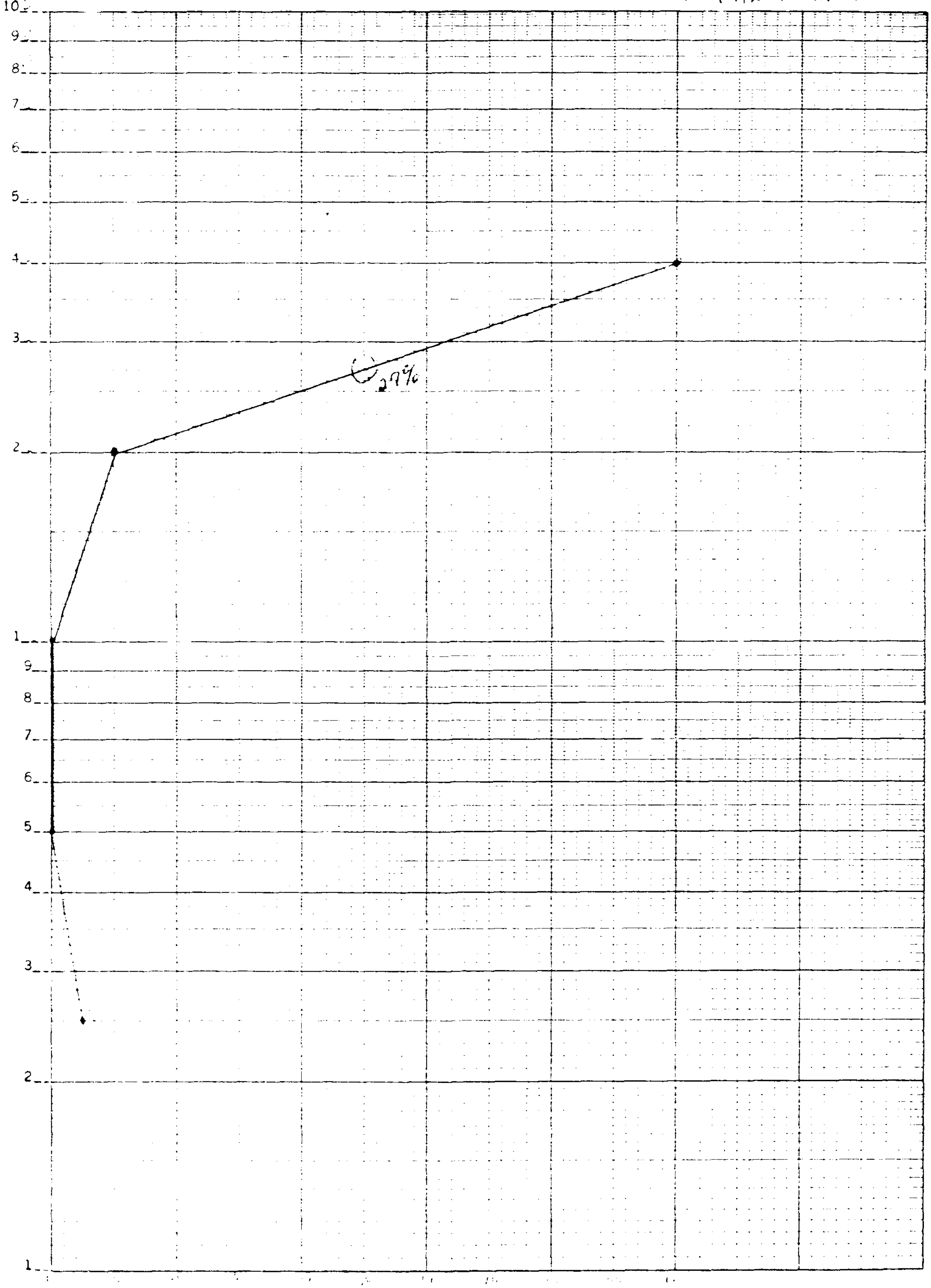
	CONTROL A	CONTROL B	2.5% A	2.5% B	5% A	5% B	10% A	10% B	20% A	20% B	40% A	40% B	A	B	A	B
NO. ALIVE:	10	10	10	9	10	10	10	10	9	9	0	0				
DISSOLV. O_2:	8.0		8.3		8.2		8.0		6.8							
PH:	8.6		8.5		8.5		8.3		8.0							
TEMPERATURE:	25.0		25.0		24.7		24.9		25.1		~~24.7~~ CLF					

96 HRS — CLF — Date: 22 July 90 — Sample #: GN 700U13 — Time: 0930

	CONTROL A	CONTROL B	2.5% A	2.5% B	5% A	5% B	10% A	10% B	20% A	20% B	40% A	40% B	A	B	A	B
NO. ALIVE:	10	10	10	9	10	10	10	10	9	9	0	0				
DISSOLV. O_2:	8.2		8.1		7.7		7.3		6.5							
PH:	8.3		8.4		8.3		8.3		8.0							
TEMPERATURE:	24.3		24.7		24.5		24.5		24.6		~~24.7~~ CLF					

DATA ENTERED BY: ______ DATA VERIFIED BY: [signature] DATE: 24 Jul 90

LAJAS
FATHEAD MINNOW



-Wear gloves with this sample + insure ventilation!

ENVIRONMENTAL SAMPLING DATA

OEHL USE ONLY

(Use this space for mechanical imprint) Could not reach you by autovon. Col B wants 48 or 96 hr fathead minnow. This is bad stuff. He said to find LD_{50} to determine dilutions.

SAMPLING SITE IDENTIFIER (AFR 19-7): 0669 NO XXX

BASE WHERE SAMPLE COLLECTED: Lajes Azores

SAMPLING SITE DESCRIPTION: Water Bioassay Sludge Pit

DATE COLLECTION BEGAN (YYMMDD): 901011

TIME COLLECTION BEGAN (24 hour clock): 0930

COLLECTION METHOD: [x] GRAB [ ] COMPOSITE ______ HOURS

MAIL REPORTS TO (circle if changed):

ORIGINAL	0253 ATHEH/EQE Bldg 1751 Brooks AFB
COPY 1	
COPY 2	

SAMPLE COLLECTED BY (Name, Grade, AFSC): Mary K Fields TSgt 90770

SIGNATURE: Mary K Fields

AUTOVON: 246.2892

REASON FOR SUBMISSION: E O

A ACCIDENT/INCIDENT R ROUTINE/PERIODIC C COMPLAINT N NPDES F FOLLOWUP/CLEANUP O OTHER (specify) Character

BASE SAMPLE NUMBER: GN 90 0619

OEHL PID:

ANALYSES REQUESTED (Check appropriate blocks)

GROUP A							
Ammonia	00610	Hardness	00900	Silica	00955	2, 4, 5-T	39740
Chemical Oxygen Demand	00340	Iron	01045	Specific Conductance	00095	2, 4, 5-TP-Silvex	39760
Kjeldahl Nitrogen	00625	Lead	01051	Sulfate	00945		
Nitrate	00620	Magnesium	00927	Surfactants-MBAS	38260		
Nitrite	00615	Manganese	01055	Turbidity	00076		
Oil & Grease	00560	Mercury	71900				
Organic Carbon	00680	Nickel	01067				
Orthophosphate	00671	Potassium	00937				
Phosphorus, Total	00665	Selenium	01147	GROUP H			
		Silver	01077	Aldrin	39330		
GROUP D		Sodium	00929	BHC Isomers	39340		
Cyanide, Total	00720	Thallium	01059	a-BHC	39337		
Cyanide, Free	00722	Zinc	01092	b-BHC	39338		
				d-BHC	34259		
GROUP E				Chlordane	39350	GROUP J	
Phenols	32730	GROUP G		DDT Isomers	39370	Sulfides	00745
		Acidity, Total	70508	p, p-DDD	39310		
GROUP F		Alkalinity, Total	00410	p, p-DDE	39320		
		Alkalinity, Bicarbonate	00425	p, p-DDT	39300		
Antimony	01097	Bromide	71870	Dieldrin	39380		
Arsenic	01002	Carbon Dioxide	00405	Dursban	77969		
Barium	01007	Chloride	00940	Endrin	39390		
Beryllium	01012	Color	00080	Heptachlor	39410		
Boron	01022	Fluoride	00951	Heptachlor Epoxide	39420		
Cadmium	01027	Residue, Total	00500	Lindane	39782		
Calcium	00916	Residue, Filterable (TDS)	70300	Methoxychlor	39480		
Chromium, Total	01034	Residue, Nonfilterable	00530	Pramitol (Pramaton)	XY4200000		
Chromium VI	01032	Residue, Settleable	50085	Toxaphene	39400		
Copper	01042	Residue, Volatile	00505	2, 4-D	39730		

ON SITE ANALYSES

PARAMETER		VALUE
Flow	50050	mgd
Chlorine, Total	50060	0 mg/l
Dissolved Oxygen	00300	mg/l
pH	00400	4.68 units
Temperature	00010	24 C
Odor	00086	
Iodide	71865	
Sulfite	00740	

REMARKS: Bioassay 48 hr 96 hr. My # @ Lajes are 735 1410 x 6206

AF FORM 2752A FEB 85 AF FORMS 2752A AND 2752B, FEB 85, REPLACE AF FORM 2752, JAN 81, WHICH WILL BE USED

APPENDIX B

AFOEHL Sampling Results Data Sheets

PARAMETERS		[illegible]	[illegible]	[illegible]
SET. SOLIDS	ug L			
TSS	ug L			
VSS	ug L			
As	ug L	<0.1	<0.1	<0.1
Ba	ug L	<1.0	<1.0	<1.0
Be	ug L			
Cd	ug L	<0.1	<0.1	<0.1
Ca	ug L			
Cr	ug L	<0.1	0.10	0.40
Cu	ug L			
Fe	ug L			
Mn	ug L			
Ni	ug L			
Zn	ug L			
Al	ug L			
Co	ug L			
Ti	ug L			
Vd	ug L			
Mo	ug L			
Hg	ug L	<0.01	<0.01	<0.01
Se	ug L	<0.01	<0.01	<0.01
Mg	ug L			
Pb	ug L	<0.3	<0.3	<0.3
Ag	ug L	<0.1	<0.1	<0.1
COD	mg L			
TOC	mg L			
O&G (418.1)	mg L	6080.00	2912.00	1592.00
O&G (Ir)	mg L	6560.00	6360.00	1848.00
NH3	mg L			
TKN	mg L			
NITRATES	mg L			
NITRITES	mg L			
O-PHOSPHATE	mg L			
T. PHOS	mg L			
PHENOL	mg L			

[illegible] SITES WET SLUDGE [illegible]

PARAMETERS		13	1[illegible]	4[illegible]
pH	units	4.[illegible]	4.6[illegible]	4.6[illegible]
1,2 DICHLOROBENZENE				
1,3 DICHLOROBENZENE				
1,4-DICHLOROBENZENE				
ETHYL BENZENE				
CHLOROBENZENE				
TOLUENE				
BENZENE				
BROMODICHLOROMETHANE				
BROMOFORM				
CARBON TETRACHLORIDE				
CHLOROBENZENE				
CHLOROETHANE				
DICHLORODIFLUOROMETHANE				
1,1 DICHLOROETHANE				
1,2 DICHLOROETHANE				
1,1 DICHLOROETHENE				
TRANS-1,2, DICHLOROETHENE				
1,2-DICHLOROPROPANE				
CIS 1,3 DICHLOROPROPENE				
TRANS 1,3 DICHLOROPROPENE				
METHYLENE CHLORIDE				
1,1,2,2 - TETRACHLOROETHANE				
TETRACHLOROETHYLENE				
1,1,1-TRICHLOROETHANE				
TETRACHLOROETHYLENE				
1,1,1-TRICHLOROETHANE				
1,1,2-TRICHLOROETHANE				
TRICHLOROETHYLENE				
TRICHLOROFLUOROMETHANE				
VINYL CHLORIDE				
BROMOETHANE				
2-CHLOROETHYL VINYL ETHER				

8 SITES FOR WET SLUDGE PIT WATE 1-8

PARAMETERS		1	2	3	5	6	7	8
SET. SOLIDS	ug/L							
TSS	ug/L							
VSS	ug/L							
As	ug/L	<0.1	<0.1	<0.1	<0.1	<100.00	<100.00	
Ba	ug/L	<1.0	<1.0	<1.0	<1.0	<100.00	129.00	
Be	ug/L					<100.00	<100.00	
Cd	ug/L	<0.1	<0.1	0.50	<0.1	<100.00	<100.00	
Ca	ug/L					22500.00	23200.00	
Cr	ug/L		<0.1	0.70	<0.1	<100.00	<100.00	
Cu	ug/L					<100.00	<100.00	
Fe	ug/L					7.71	28020.00	
Mn	ug/L					1.03	1225.00	
Ni	ug/L					<100.00	<100.00	
Zn	ug/L					360.00	792.00	
Al	ug/L					482.00	2097.00	
Co	ug/L					<100.00	<100.00	
Ti	ug/L					<100.00	725.00	
Vd	ug/L					<100.00	<100.00	
Mo	ug/L					<100.00	<100.00	
Hg	ug/L	<0.01	<0.01	<0.01	<0.01	<1.00	<1.00	
Se	ug/L	<0.01	<0.01	<0.01	<0.01			
Mg	ug/L					7800.00	8200.00	
Pb	ug/L	<0.3	<0.3	<0.3	<0.3	391.00	983.00	
Ag	ug/L	<0.1	<0.1	<0.1	<0.1	<5.00	<5.00	
COD	mg/L					1075.00	2400.00	
TOC	mg/L					360.00	360.00	
O&G (418.7)	mg/L		196.00			7.40	1.10	
O&G (Ie)	mg/L		318.00			11.60	8.50	
NH3	mg/L					<0.20	<0.20	
TKN	mg/L					1.10	1.10	
NITRATES	mg/L					<0.10	<0.10	
NITRITES	mg/L					<0.20	<0.20	
O-PHOSPHATE	mg/L					0.18	0.60	

8 SITES FOR WET SLUDGE PIT WATER 1-8

PARAMETERS		1	2	3	5	6	7	8
T. PHOS	mg L					0.21	0.60	
PHENOL	mg/L					270.00	260.00	
pH	units	4.68						
1,2 DICHLOROBENZENE								<1.00
1,3 DICHLOROBENZENE								<0.50
1,4-DICHLOROBENZENE								<0.70
ETHYL BENZENE								<0.30
CHLOROBENZENE								<0.60
TOLUENE								<0.30
BENZENE								<0.50
BROMODICHLOROMETHANE								<0.40
BROMOFORM								8.10
CARBON TETRACHLORIDE								<0.50
CHLOROETHANE								<0.90
CHLOROFORM								<0.30
CHLORMETHANE								<0.80
CHLORDIBROMOETHANE								<0.50
DICHLORODIFLUOROMETHANE								<0.90
1,1 DICHLOROETHANE								<0.40
1,2 DICHLOROETHANE								<0.30
1,1 DICHLOROETHENE								<0.30
TRANS-1,2, DICHLOROETHENE								<0.50
1,2-DICHLOROPROPANE								<0.30
CIS 1,3 DICHLOROPROPENE								<0.50
TRANS 1,3 DICHLOROPROPENE								<0.50
METHYLENE CHLORIDE								<0.40
1,1,2,2 - TETRACHLOROETHANE								<0.50
TETRACHLOROETHYLENE								<0.60
1,1,1-TRICHLOROETHANE								<0.50
TETRACHLOROETHYLENE								<0.50
1,1,1-TRICHLOROETHANE								<0.50
1,1,2-TRICHLOROETHANE								<0.40

8 SITES FOR WET SLUDGE PIT WATER 1-8

PARAMETERS	1	2	3	5	6	7	8
TRICHLOROETHYLENE							<0.90
TRICHLOROFLUOROMETHANE							<0.90
VINYL CHLORIDE							<0.90
BROMOETHANE							
2-CHLOROETHYL VINYL ETHER							

FN:WETSLUD.PIT

8 SITES FOR WET SLUDGE PIT WATER 1-8

PARAMETERS	1	2	3	5	6	7	8
TRICHLOROETHYLENE							<0.90
TRICHLOROFLUOROMETHANE							<0.90
VINYL CHLORIDE							<0.90
BROMOETHANE							
2-CHLOROETHYL VINYL ETHER							

FN:WETSLUD.PIT

		DRY SOIL SAMPLES						
TEST	UNITS	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6	SITE 7
Aldrin	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
alpha-BHC	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
beta-BHC	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
delta-BHC	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
gamma-BHC	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
DDD	ug/g	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Chlordane	ug/g	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014
DDE	ug/g	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
p,p-DDT	ug/g	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Dieldrin	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Endosulfan I	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Endosulfan II	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Endosulfan sulfate	ug/g	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Endrin	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Endrin aldahyde	ug/g	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Heptachlor	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Heptachlor epoxide	ug/g	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Toxaphene	ug/g	<0.240	<0.240	<0.240	<0.240	<0.240	<0.240	<0.240
Aroclor 1016	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1221	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1232	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1242	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1248	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1254	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1260	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

TEST	UNITS	WET SLUDGE SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6	SITE 7
Aldrin	ug/g	<0.002	0.178	0.019				
alpha-BHC	ug/g	<0.151	0.048	<0.002				
beta-BHC	ug/g	<0.002	0.319	0.083				
delta-BHC	ug/g	2.05	<0.002	<0.002				
gamma-BHC	ug/g	<0.002	<0.002	0.110				
DDD	ug/g	0.043	0.168	<0.008				
Chlordane	ug/g	<0.014	<0.014	<0.014				
DDE	ug/g	0.010	<0.008	0.016				
p,p-DDT	ug/g	0.104	0.459	<0.008				
Dieldrin	ug/g	<0.002	0.111	<0.002				
Endosulfan I	ug/g	<0.002	0.024	<0.002				
Endosulfan II	ug/g	0.115	<0.002	0.016				
Endosulfan sulfate	ug/g	<0.008	<0.008	<0.008				
Endrin	ug/g	0.012	<0.002	0.011				
Endrin aldahyde	ug/g	<0.004	0.065	<0.004				
Heptachlor	ug/g	0.206	0.670	<0.002				
Heptachlor epoxide	ug/g	5.83	<0.002	6.48				
Toxaphene	ug/g	<0.240	<0.240	<0.240				
Aroclor 1016	mg/kg	<0.1	<0.1	<0.1				
Aroclor 1221	mg/kg	<0.1	<0.1	<0.1				
Aroclor 1232	mg/kg	<0.1	<0.1	<0.1				
Aroclor 1242	mg/kg	<0.1	<0.1	<0.1				
Aroclor 1248	mg/kg	<0.1	<0.1	<0.1				
Aroclor 1254	mg/kg	<0.1	<0.1	<0.1				
Aroclor 1260	mg/kg	<0.1	<0.1	<0.1				

		DRY SOIL SAMPLES					
PARAMETERS		1	2	3	5	6	7
SET. SOLIDS	ug/L						
TSS	ug/L						
VSS	ug/L						
As	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ba	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Be	ug/L						
Cd	ug/L	<0.1	<0.1	0.50	<0.1	<0.1	<0.1
Ca	ug/L						
Cr	ug/L	<0.1	<0.1	0.70	<0.1	<0.1	<0.1
Cu	ug/L						
Fe	ug/L						
Mn	ug/L						
Ni	ug/L						
Zn	ug/L						
Al	ug/L						
Co	ug/L						
Ti	ug/L						
Vd	ug/L						
Mo	ug/L						
Hg	ug/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Se	ug/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mg	ug/L						
Pb	ug/L	<0.3	<0.3	<0.3	<0.3	0.3	<0.3
Ag	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
COD	mg/L						
TOC	mg/L						
O&G (418.7)	mg/L		196.00				
O&G (Ie)	mg/L		318.00				
NH3	mg/L						
TKN	mg/L						
NITRATES	mg/L						
NITRITES	mg/L						
O-PHOSPHATE	mg/L						

PARAMETERS	PRAIA RESIDENTIAL DRINKING WATER
TRICHLOROETHYLENE	<0.90
TRICHLOROFLUOROMETHANE	<0.90
VINYL CHLORIDE	<0.90
BROMOETHANE	
2-CHLOROETHYL VINYL ETHER	

PARAMETERS		SITES FOR WET SLUDGE PIT 1S	2S	3S	4*	5**	6	7
SET. SOLIDS	ug/L	940	790	930				
TSS	ug/L	1863	270	340			61	295
SPECIFIC GRAVITY		1.12	1.04	1.14			1.05	1.01
VSS	ug/L							
As	ug/L	<0.1	<0.1	<0.1		<0.1	<100.00	<100.00
Ba	ug/L	<1.0	<1.0	<1.0		<1.0	<100.00	129.00
Be	ug/L						<100.00	<100.00
Cd	ug/L	<0.1	<0.1	<0.1		<0.1	<100.00	<100.00
Ca	ug/L						22500.00	23200.00
Cr	ug/L	<0.1	0.1	0.4		<0.1	<100.00	<100.00
Cu	ug/L						<100.00	<100.00
Fe	ug/L						7.71	28020.00
Mn	ug/L						1.03	1225.00
Ni	ug/L						<100.00	<100.00
Zn	ug/L						360.00	792.00
Al	ug/L						482.00	2097.00
Co	ug/L						<100.00	<100.00
Ti	ug/L						<100.00	725.00
Vd	ug/L						<100.00	<100.00
Mo	ug/L						<100.00	<100.00
Hg	ug/L	<0.01	<0.01	<0.01		<0.01	<1.00	<1.00
Se	ug/L	<0.01	<0.01	<0.01		<0.01		
Mg	ug/L						7800.00	8200.00
Pb	ug/L	<0.3	<0.3	<0.3		0.4	391.00	983.00
Ag	ug/L	<0.1	<0.1	<0.1		<0.1	<5.00	<5.00
BOD	mg/L						398	415
COD	mg/L						1175	2150
TOC	mg/L						360.00	360.00
O&G (418.7)	mg/L	6080.00	2912.00	1592.00		196.00	7.40	1.10
O&G (Ir)	mg/L	6560.00	6360.00	1848.00		318.00	11.60	8.50
NH3	mg/L						<0.20	<0.20
TKN	mg/L						1.10	1.10
NITRATES	mg/L						<0.10	<0.10

NITRITES	mg/L	<0.20	<0.20
O-PHOSPHATE	mg/L	0.18	0.60
T. PHOS	mg/L		
PHENOL	mg/L		

4* No results available
5** Site located between sites 3 and 4

BIOOXIDATION DATA

DATE	SET S	BOD	BOD AVG	COD	COD AVG	MLSS	MLVSS
18	NA	792 420 318 207	416	2122 2517	2319	404	306
19	NA	528 396 390	438	7832 6936	7384	2692	882
20	10	825 650 825 700	750	9365 7300	8333	1906	864
23	11	312 288 270	290	3557	3557	1860	854
24	26	312 396 366	358	6969 6239	6604	5888	2300
25	34	414 408	412	6039 6130	6084	5280	2008
26	28	984 780	882	5680 5292	5485	8508	3904
27	40	936 768 378	694	8297 6839	7568	3905	1570
30	37	NA	NA	9464 9171	9464	6220	2525
31	28	NA	NA	7000 6289	6645	3905	1595
1 Aug	NA	NA	NA	NR	NR	6435	2705
8	31	NA	NA	6890	7592	1040	730

				8294			
9	42	NA	NA	5897 5623	5760	4630	1830
10	41	NA	NA	4950 6112	5531	2208	828
23	41	336 192 132	220	7876 8604	8240	8588	3480
24	20	336 180 156	224	5614 6321	5967	5280	2240

SLUDGE INCINERATION

TRIAL #	TEMP C	DRY WT. BEFORE	DRY WT. AFTER	% REDUCTION
1	200	2.0015	1.5687	21.6
2	250	2.0026	1.2502	37.6
3	300	2.0047	1.2902	35.6
4	350	1.9996	1.1460	42.3

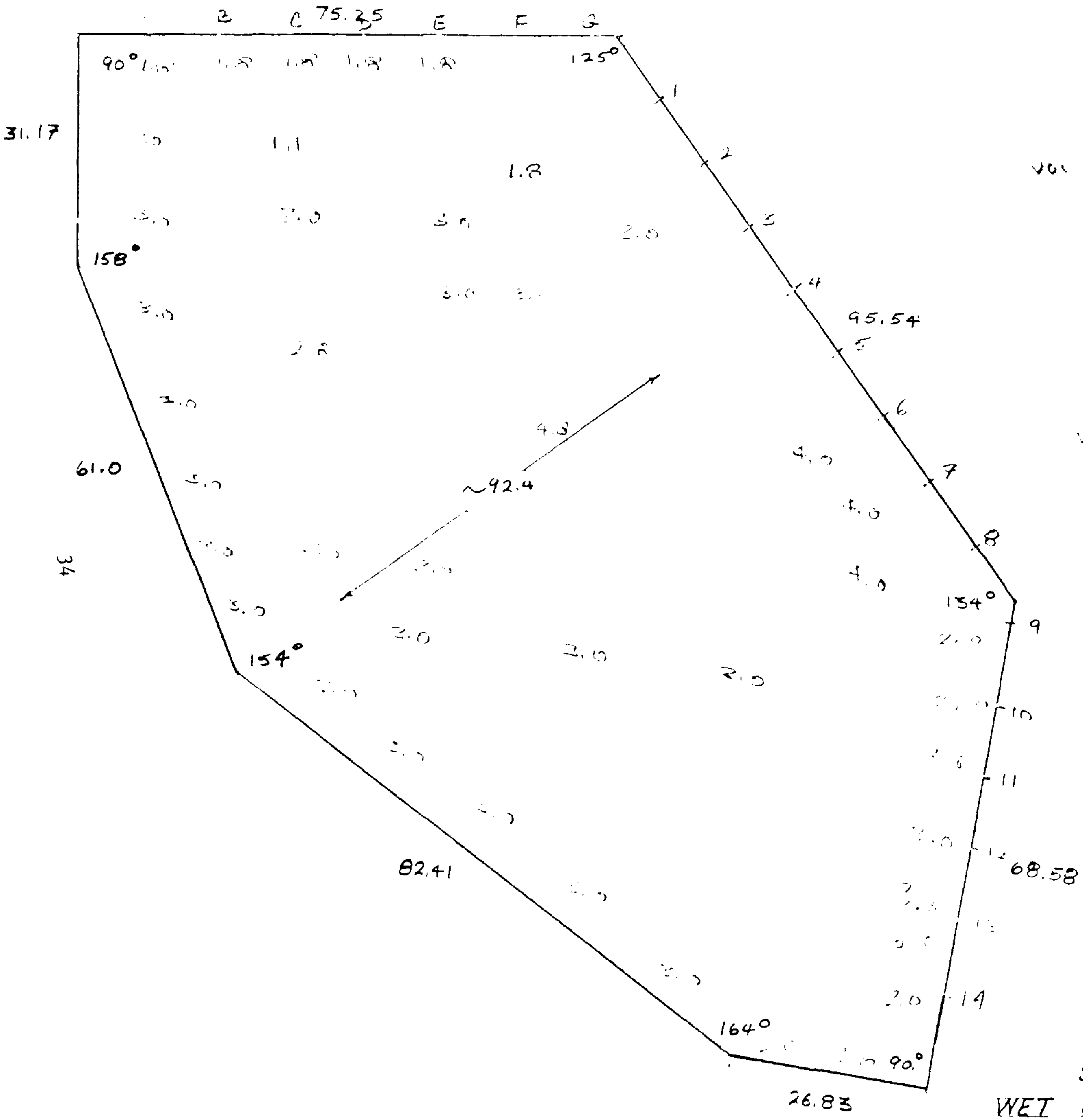
ADSORPTION ISOTHERM

WT CARBON (M) mg/100 mls	COD mg/L	x mg/L	X mg/100 mls	X/M
[illegible]	1253	–	–	–
5	1194	59	5.9	1.18
10	1183	70	7.0	0.70

20	1131	122	12.2	0.61
30	1094	159	15.9	0.53
40	1097	156	15.6	0.39

APPENDIX C

Wet Sludge Pit Wastewater Volume Computations



[illegible]

$4\,[illegible] + 13[illegible] = [illegible] - 8[illegible]$

$= \frac{115.7}{43} = 2.7$

Vol sludge water = $(A_T + A_B)/2 \times 2.7$

$(12,[illegible] + 10,[illegible])/2 \times 2.7$

Vol [illegible] = 31,300.7 ft²

31,300.7 ft² × [illegible] =

2[illegible],129.2 gals

Vol [illegible]

Vol [illegible] +

[illegible]

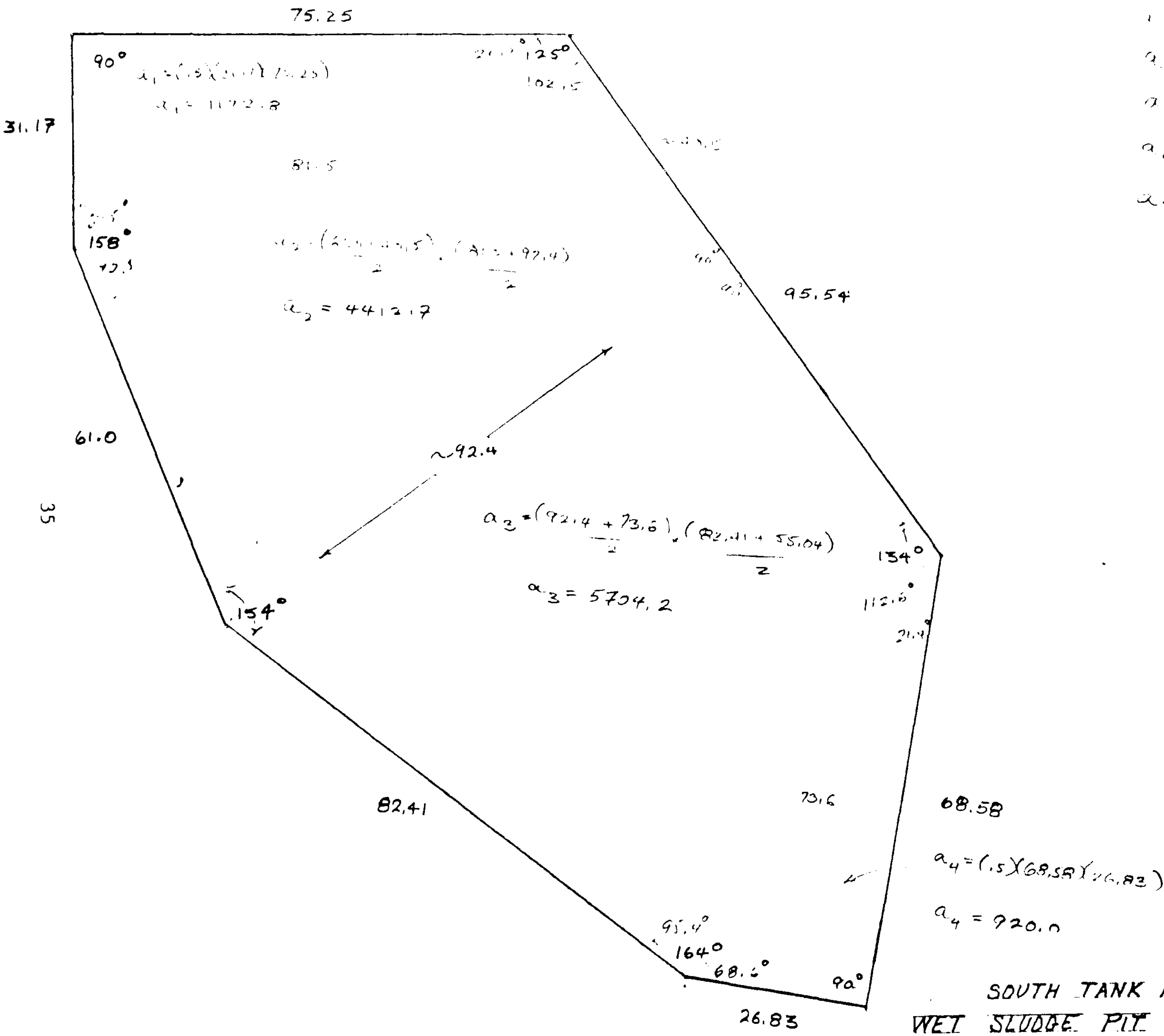
$(12,[illegible] + 10,[illegible])/2 \times (2.7 - .67)$

+ 5,5[illegible] ft² × [illegible] = 27890 [illegible]

× [illegible] = 208.64 gals

SOUTH TANK FARM

WET SLUDGE PIT BOTTOM DEPTHS



AREA (ft^2)

$a_1 = 1172.8$

$a_2 = 4412.7$

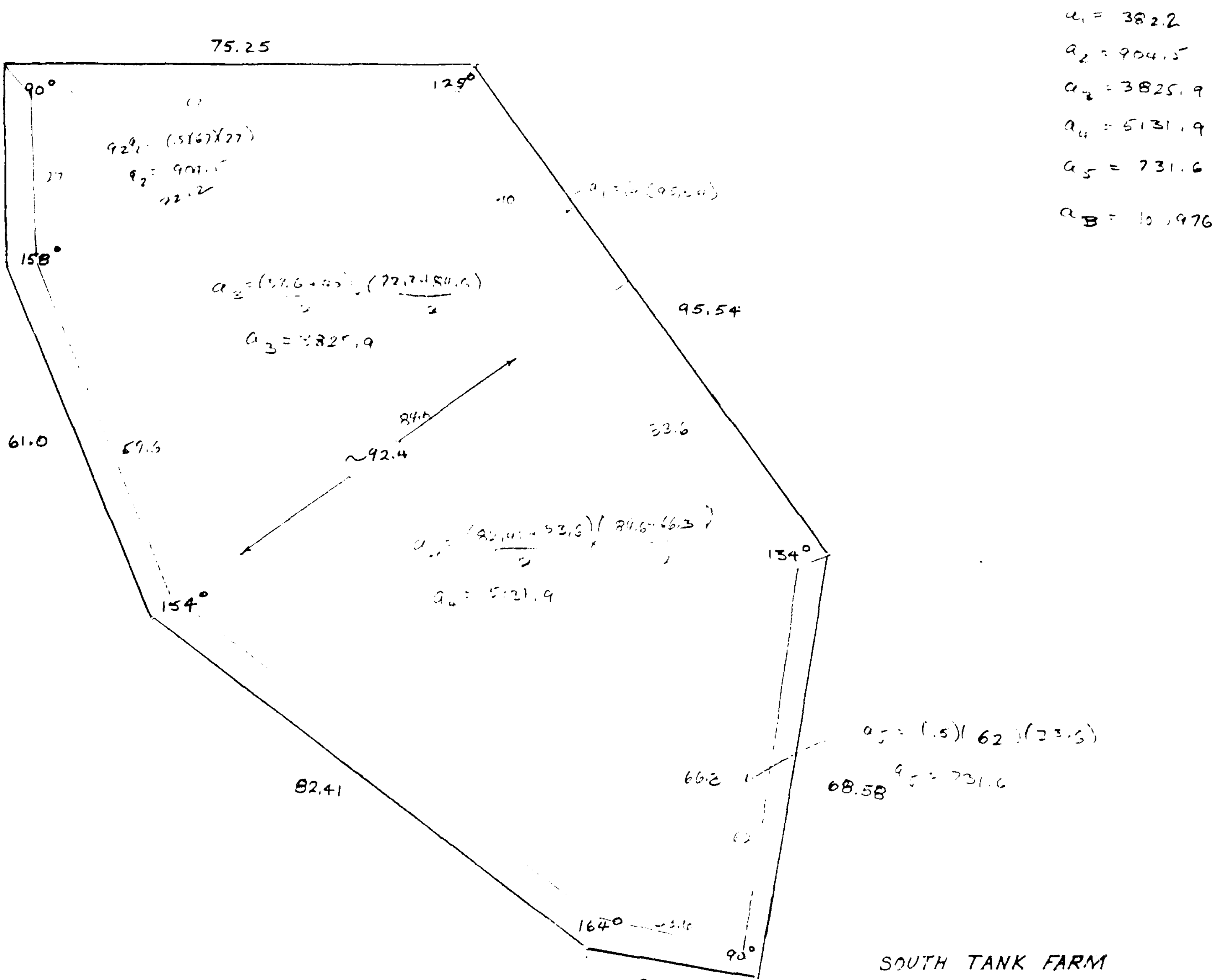
$a_3 = 5704.2$

$a_4 = 920.0$

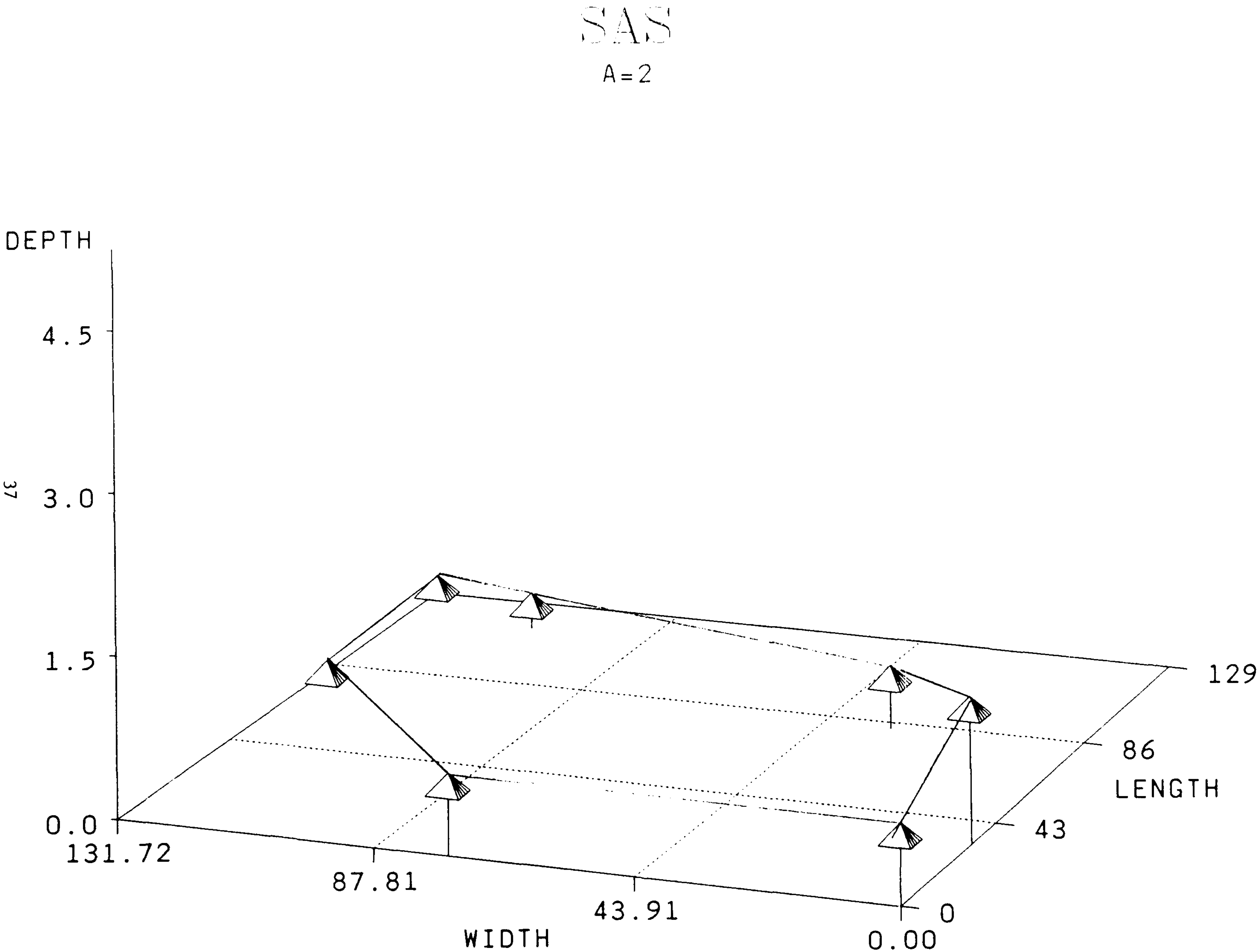
$a_T = 12209.7$

SOUTH TANK FARM

WET SLUDGE PIT OUTSIDE DIMENSIONS



SOUTH TANK FARM
WET SLUDGE PIT BOTTOM DIMENSIONS


SAS
A=2
DEPTH
4.5
3.0
1.5
0.0
131.72
87.81
43.91
0.00
WIDTH
0
43
86
129
LENGTH

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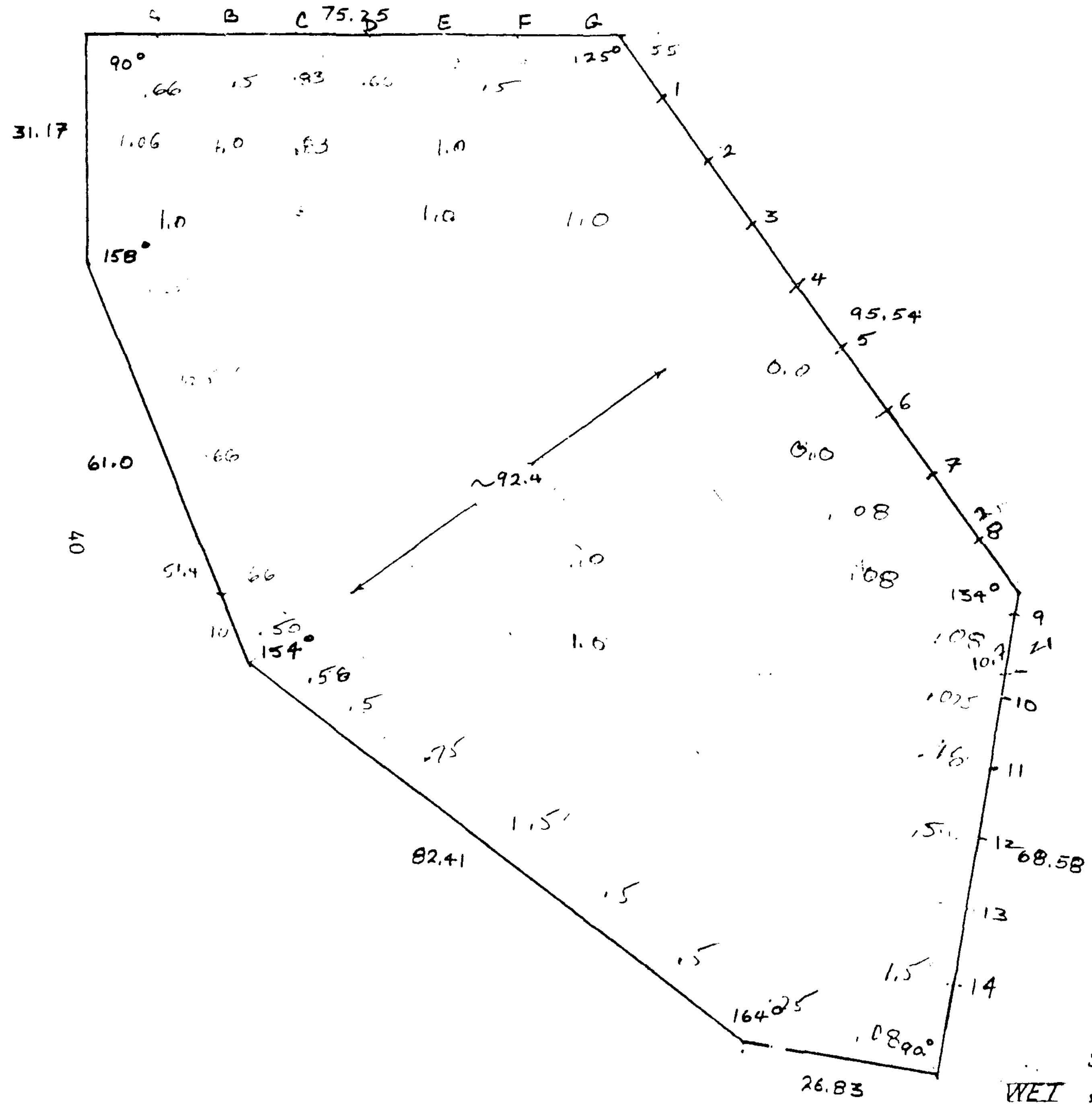
APPENDIX D

Wet Sludge Pit Sludge Volume Computations



AVERAGE DEPTH FROM SURVEY

2(1.5) + 2(1.25) + 1(1.06) + 6(1.0)

+ 1(.83) + 1(.75) + 4(.66) =

+ 1(0.58) + 7(0.50) + 1(0.25)

+ 1(0.16) + 4(0.08)

AVG. DEPTH [illegible] 0.67

SOUTH TANK FARM

WET SLUDGE PIT SLUDGE DEPTHS

% liquid in sludge $\qquad$ % H_2O

#1	15,66 g 25,0 − 15,66 = 9.34 water	57,35
#2	21.10 .3 g	78,97
#3		90,90
#4		82,26
#5		80,64
	AVG:	78,03

#1 = 136,6177 − 120,9585 = 15,6592 g H_2O $\frac{1.149 \text{ sludge}}{1 \text{ g } H_2O}$

136,7177 − 109,3114 = 27,3063 − 15,6592 = 11,6471 d.s.

% moisture

128,1425 − 105,3484 = 22,7941 (W.S) − (128,1425 − 107,0379) (H_2O)

= 1,6893 (D.S)

#3 131,8418 − 108,4246 = 23,4172 (W.S) − (21,2872) (H_2O) = 2,13 (D.S)

#4 142,3062 − 117,9806 = 24,3256 − (20,1049) = 4,22

#5 142,586 − 118,7066 24,874 − (20,0589) 4,8151

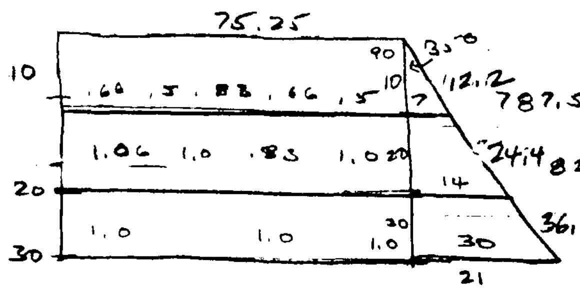
10L SLUDGE 5584,71 ft^3 × $\frac{.22 \text{ D.S}}{1.0 \text{ SLUDGE}}$ = 1228,6 ft^3

1228,6 ft^3 × $\frac{1 \text{ yd}^3}{27 \text{ ft}^3}$ = 45,51 yd^3

SLUDGE DEPTHS

ft	#	
1.5	2	3.0
1.25	2	2.5
1.06	1	1.06
1.0	6	6.00
0.83	1	.83
0.75	1	.75
0.66	4	
0.58	1	2.64
0.50	7	3.50
0.25	1	.25
0.16	1	.16
0.08	4	.08
	31	20.77

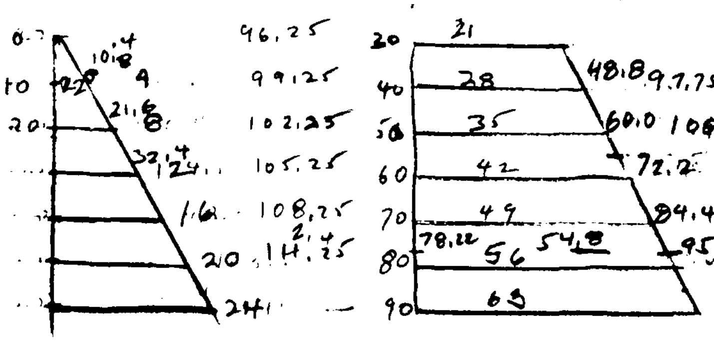
AVG 0.67



787.5 x (0.63) = 496.125

822.5 x (0.97) = 799.88

857.5 x (1.0) = 857.5



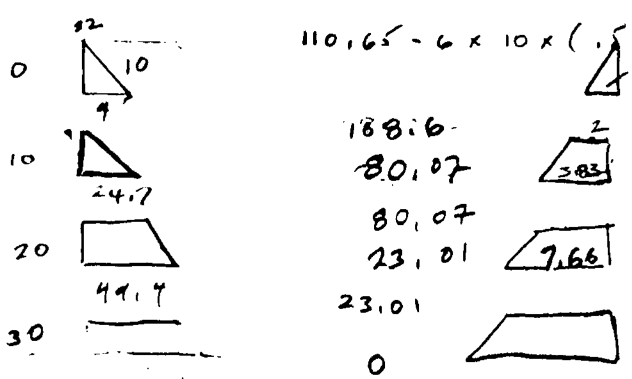
97.75 x 10 x (.625) = 610.9

100.75 x 10 x (.875) = 629.8

103.75 x 10 x .33 = 342.4

106.75 x 10 x .33 = 352.3

104.2 x 7.8 x .33 = 281.1



110.65 - 6 x 10 x (.5 + 1.0 + .08/2) = 567.0

188.6
80.07

94.34 x .28 x 10 = 291.2

80.07
23.01

51.54 x 10 x (.45) = 234.5

23.01
0

11.5 x 10 x 1 = 115.0

$.5 \times 13.8 \times 23.0 \times (125 * .08/2) = 26.18$

496.13

799.88

857.5

610.9

629.8

343.4

352.3

281.1

567.0

271.2

234.5

115.0

26.0

5584.71 ft^3

$$\frac{(\text{AREA}_T + \text{AREA}_B)}{2} \times 0.67' = \frac{(12{,}209.7 + 10{,}976)}{2} \times 0.67'$$

VOL SLUDGE = 7767.2 ft^3

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